Vowel Production in Children and Adults with Williams Syndrome

A Senior Honors Thesis

Presented in partial fulfillment of the requirements for graduation with Distinction in Speech and Hearing Science in the Undergraduate Colleges of The Ohio State University

By

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Acknowledgements

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Abstract

Williams Syndrome (WS) is a genetic condition that typically causes mild to severe learning and cognitive disabilities. This study examines the extent to which individuals with WS have atypical uses of segmental aspects of speech production—specifically, the acoustic characteristics of individual vowels compared to vowels produced by typically developing children and typical adults. The main interest of the study was in whether individuals with WS acquired the salient characteristic features of their regional dialect. Six participants who had been diagnosed with WS participated in a word-picture naming test. The set of isolated words produced and recorded represented high-frequency English monosyllabic words which included 11 basic monophthongal vowel phonemes and 3 true diphthongs. Three regional varieties of American English were tested: the dialect spoken in Central Ohio (Columbus area), Northern Ohio (Cleveland area), and in West Virginia (Huntington area). The results show that individuals with WS acquire only some features of their regional variety and show highly variable production patterns.

Chapter 1

Introduction and Literature Review

Williams Syndrome (WS) is a neurodevelopmental disorder caused by the deletion of approximately 26 genes on chromosome 7 (Peoples et al., 2000). The prevalence of this disorder is estimated to 1/7,500 (Stromme, Bjornstad, & Ramstad, 2002) and is commonly associated with a specific set of physical features, heart disease, connective tissue abnormalities (due to the deletion of the elastin gene), and developmental delays (Morris, 2006). Children diagnosed with WS often share a specific personality/behavioral profile and similar levels of cognition.

Cognition in children with WS is identified as being ranked in the mild intellectual disability range (Martens, Wilson, & Reutens, 2008) with various strengths and weaknesses. Some strengths include language and non-verbal reasoning, and concrete receptive and expressive vocabulary. Weaknesses include, but are not limited to, pragmatics of language (maintaining conversation topics) and visuospatial construction (Mervis, 2006). The behavioral profile largely consists of being overly extroverted and rarely showing stranger anxiety. These children are also likely to use these personality characteristics to avoid participating in tasks that they find challenging (Jarvinen-Parsley et al., 2008). High levels of anxiety and phobias gradually develop throughout the lifespan of children with WS despite their familiarity with social interaction. Diagnosed children tend to become uncomfortable and subject-focused on the possible events where they could struggle or expect to dislike the particular activity (Phillips & Klein-Tasman, 2009). Another diagnosis commonly reported with the behavioral aspect of WS is Attention Deficit Hyperactivity Disorder (ADHD), which continues to grow more prominently with age and often contributes to their level of anxiety (Einfeld, Tonge, & Florio, 1997).

The current study is conducted in order to provide insight on whether children and young adults diagnosed with WS are able to acquire speech patterns typical of their specific speech community. Focusing on vowel production, the study examines if indexical features such as regional dialect are present or absent in their speech. The absence of regional features will suggest that WS impairs the ability to acquire pronunciation details which characterize speech of typically developing children and typical adults.

1. Language

Language is considered a relative strength for children with WS; however, there are multiple areas that fall within the language domain that show various strengths and weaknesses. Children with WS have been found to use a lower frequency of gesturing which accounts for their delayed onset of language development. This is consistent with previous research identifying gestures as a precursor to language development (Laing et al., 2002; Singer et al., 1997). Both motor and linguistic milestones are typically delayed in WS but in various levels. Two milestones that are highly correlated with language acquisition in research by Eilers et al. (1993) include canonical babble and rhythmic hand banging.

Language strengths in children with WS include their ability to understand overall grammatical structures with demonstrations of proper use of syntax and semantics (Bellugi, Lai, & Wang, 1997; Rossen et al., 1996). In a study by Thal, Bates, and Bellugi (1989), expressive vocabulary and spontaneous language skills appeared to be relatively similar to those of typically developing and late-talking children. In another study, older children demonstrated grammatical competence and fluent language, but had more difficulty in using pragmatics, specifically in instances of maintaining a topic in conversations (Mervis, 2006). Due to their outgoing personalities and strong prominence of friendliness, conversational characteristics include stereotyped phrases, overfamiliarity, and preservative responses, which correspond with being hyperverbal (Udwin and Yule, 1990).

The results of language studies reported on individuals with WS have provided mixed results. Individuals with WS appear to show a typical (but delayed) development in areas such as complex syntax, semantics, word fluency, and expressive vocabulary. This is not unexpected considering their behavioral profile and cognitive capacity. However, these individuals seem to struggle with areas such as pragmatics, oral fluency, and reciprocal conversation, which also can be expected from their social behavior and cognition (Martens, Wilson, and Reutens, 2008).

2. Speech

Relatively little is known about speech production and perception in individuals with WS. Anatomically, elastin deficits and low muscle tone can be addressed as contributing to deviant speech characteristics (particularly harsh voice quality) that can be observed in more than half of children affected with WS. Fortunately, despite experiencing atypical aspects that can affect voice quality, most individuals with WS are intelligible in spoken language (Mervis and Velleman, 2012).

The onset of language acquisition and speech production are typically delayed in individuals with WS. This can be attributed to the lack of rhythmic productions (both linguistic and nonlinguistic) and ability to segment words in spoken language (Nazzi, Paterson, & Karmiloff-Smith, 2003). A study by Velleman et al. (2006) examined phonological development in six children with WS (18 months old). These subjects were compared with two other groups: one consisting of typically developing children, and one consisting of individuals with Down

Syndrome (DS). The experiment examined the ability to produce canonical babble syllables. The two syndrome groups produced high proportions of V-alone syllables (per babble) compared to the typically developing children, which supports the possibility of a language delay (lack of CV acquisition). The group of individuals with WS showed more variability than either typically developing or DS groups.

Delayed speech perception abilities in children with WS could partially be due to their difficulties in segmenting weak-strong words (e.g., balloon). Jusczyk, Houston, & Newsome (1999) demonstrated that typically developing infants (7.5 months old) were able to distinguish and segment strong-weak stress patterns (predominant pattern in the English language) out of ongoing speech if they had previously been exposed to the target words produced as isolated items. However, in segmenting weak-strong stress patterns, these infants were not able to accomplish this task until 10.5 months of age. In children with WS, the impact of a speech delay can be dependent on their isolated exposure to weak-strong words in spoken language. Developing an understanding of lexical stress in isolation allows the learner to focus on the targeted words without the influence of environmental elements. Jusczyk et al. (1999) discovered that children with WS were able to acquire weak-strong words without being able to segment them out of a speech stream. This can suggest that there are limited cognitive resources for children with WS to develop new vocabulary, which contributes to their slower acquisition rate relative to typically developing children. The inability to distinguish lexical stress to develop these language characteristics can contribute to the possibility of a speech delay.

3. Dialectical Vowel Variation

Acoustic characteristics of American English vowels vary as a function of regional dialect. The regional varieties spoken in the United States have been documented and characterized in the Atlas of North American English (Labov, Ash, & Boberg, 2006). Typically developing children adopt and reproduce the dialect features dominant in their speech community, including pronunciation of dialect-specific vowel variants. However, little is known if atypically developing children such as those with WS are able to construct their vowel spaces on the basis of pronunciation pattern in a given dialect region. To investigate this, three different regional varieties of American English were chosen in this study: English spoken in Central Ohio (the Midland dialect), in the northern Midwestern region (the dialect of the Northern Cities such as Cleveland, Chicago or Milwaukee) and Southern English spoken in a several Southern states such as Virginia, North Carolina, Georgia, Alabama or Texas. Acoustic features typical of these three regional varieties were characterized and detailed in several previous studies (e.g., Fox & Jacewicz, 2009; Jacewicz, Fox, & Salmons, 2011a).

The individuals with WS selected for the current study were from Central Ohio, Cleveland, and West Virginia. Vowel productions of these participants were compared with vowels of typically developing children and typical adults who represented each of the three regional dialects. However, except for the Central Ohio, the Cleveland and West Virginia productions were matched for their respective dialect features with Southeastern Wisconsin (the area between Madison and Milwaukee) and Western North Carolina (the Cullowhee area) because these data were previously recorded and available for a comparison. Although there was no direct geographic match for these two dialects, the North Midwestern and Southern vowel features were present in both. In particular, the North Midwestern vowel system (whether typical of Cleveland or Southeastern Wisconsin) was affected by the Northern Cities Shift and the

Southern vowel system (typical of either West Virginia or Western North Carolina) was affected by the Southern Shift (Labov et al., 2006). The individual vowel features typical of the three different regional varieties examined in this study are discussed in greater detail in Chapter 3.

Chapter 2

Methodology

1. Participants

Six individuals previously diagnosed with Williams Syndrome, ages 7-43, participated in this production study. There were two individuals from each of these three different regional areas: Central Ohio, West Virginia (Huntington), and Northern Ohio (Cleveland area). We will refer to these subjects only by number (maintaining participant confidentiality).

S301 is a 13 year-old male previously diagnosed with WS from Huntington, West Virginia. According to his grandmother, he attends a special education school, however, he is not a competent reader. Fortunately, he was able to complete the picture-word experiment for this study. The boy was completely deaf in his right ear and had either normal hearing or a mild hearing loss in his left ear (as reported). Individuals collecting data from his speech production and speech perception tasks reported that he often appeared confused and kept asking where he was going. In general, the session was reported as stressful to the experimenters because of the boy's confusion and fussy attitude.

S302 is a 37 year-old female previously diagnosed with WS from Huntington, West Virginia. According to the woman's mother, we learned that the subject received speech therapy as a toddler and is a high school graduate. She is a high-functioning individual and did not encounter any problems completing the picture-naming experiment. Her mother indicated that although S302 has a relatively high level of cognitive abilities, her behavioral responses make it difficult for her to do some common tasks such as driving (she is easily distracted by the scenery). She is aware of foreign accents (self-reported) and was extremely friendly with experimenters during all interactions. She spoke with a clear voice and typical American English intonation. Her responses to all questions were quick and decisive. S302 took a particular liking to the conversation that she had with one of the experimenters and asked her join her in the booth with her during testing. Overall, the testing went smoothly and no unexpected complications arose.

S303 is a 7 year-old male previously diagnosed with WS from Cleveland, Ohio. According to the boy's parents he did not pass his newborn hearing screening. He was diagnosed early on with a speech delay and has been receiving speech therapy since the diagnosis. He has tubes placed in both ears to reduce difficulties form middle ear problems. He is a bilingual child with English as his L1 and Portuguese as his L2. He and his mother exchanged multiple words in Portuguese (her native language) during the experimental session, presumably to get the boy's attention when it strayed. He completed the picture-naming experiment, but because of his high level of ADHD, it was particularly difficult for him to complete the task. When asked a question, the boy often provided no answer and responded by asking another question. After the father was brought into the testing booth, the boy was more attentive and was willing to repeat words. Often these words were produced at a very high intensity level (producing peak clipping in the recording) which necessitated re-recording. Overall, it was a challenge to complete the experiment because of the boy's inability to be fully attentive during the experiment.

S304 is a 7 year-old female previously diagnosed with WS from Hudson, Ohio (a town near Cleveland). According to the girl's parents, S304 had been in speech therapy since the age of two but does not have any hearing problems. She is in the special education program for first grade and cannot read. She was developing a cold and had a degree of resulting hypo-nasality at the time of testing. During the picture-naming task S304 said several words too loud and was asked to repeat them; otherwise, she was able to complete the task with no problems. In several of the recordings, the listener can hear an experimenter speaking in the background encouraging and directing her to use the correct picture name.

S305 is an 11 year-old male previously diagnosed with WS from Columbus, Ohio. According to his grandmother, the boy has a private tutor and was, at the time of testing, focusing on phonics. He is currently in the 5th grade and gets some assistance during school hours. The boy has had a hearing aid on his left ear for the past 3 years. S305 was not overly engaging with the experimenters, but was willing to do what was asked of him. He completed the picture-naming task with marginal clarifications needed on some pictures. He was asked to repeat several words because his intensity level was too low (he also had a low fundamental frequency). The experiment was conducted with minimal complications and he was able to remain attentive for the duration of the task.

S306 is a 43 year-old male previously diagnosed with WS from Lima, Ohio. According to the family member who brought him to the testing facility, S306 is a high school graduate and is able to sign his own permission forms as well as hold employment at Meijer (a common grocery store chain). He is high functioning and was mostly independent. He completed the picture-naming task with minimal complications, which mainly dealt with an over-exaggeration of the picture. For example, instead of saying "doll," he would refer to the picture as "a doll with a red polka dot dress." He displayed a particular interest in detail in many instances. He followed directions well and appeared more than happy to participate in the task.

2. Experiment

a. Stimuli

High-frequency words were chosen for the picture-name experiment because of their expected familiarity in an individual's vocabulary. Monosyllabic words were used, such as "cat, dog, boot, cow, shirt," as well as multisyllabic words such as "table, apple," Plural forms of these words were also used, for example, "boots, apples".

Monosyllabic	Multisyllabic	Plural
/kæt/	/teɪbl/	/buts/
/but/	/æpl/	/æpls/

Pictures used to represent these words consisted of one single image that had high probability of being named correctly. The Appendix includes all pictures (together with the expected response) used in the experiment—there were 43 different pictures.

b. Procedure

Each participant was escorted into sound-attenuating booth. Before the task was performed, the experiment was displayed on the main computer outside of the booth as well as on the testing computer inside the booth where the participant and experimenter were positioned. The experimenter directed the experiment by being responsible for the computer mouse and asked the participant if they were ready before selecting start for each picture. Once the picture displayed on the computer screen and the mouse selected "Start", the participant recorded a one-word response to the visual stimulus. If needed, some verbal help was given by the experimenter if the participants included details in their responses and were prompted once more to only give one-worded answers. This procedure was carried out for the all 43 pictures. All of the pictures used along with a screenshot of the picture-name experiment can be found in the Appendix.

c. Controls

From an existing database analyzed by Dr. Fox and Dr. Jacewicz (Fox & Jacewicz, 2009; Jacewicz, Fox & Salmons, 2011b), we compared the vowel productions of individuals with WS with typically developing children and typical adults. Individuals with WS, a male child and adult, from central Ohio were compared with existing data analysis of young boys from central Ohio. The participants with WS from Huntington, West Virginia were compared with individuals (women and boys) from North Carolina (who spoke similar, although not necessarily an identical dialect). The focus in these comparisons was whether or not all speakers were participating in the Southern Vowel Shift (Labov et al., 2006). The third comparison was between the speech of the participants from northern Ohio and the control data collected from southeastern Wisconsin speakers (both geographical regions are part of the Inland North dialect area). The primary focus in comparing these two groups was the extent to which the Northern Vowel Shift (Gordon, 2001) is found within individual participants.

3. Formant Analysis

Of interest in each graph is the trajectory of the formant frequency change over each vowel's duration in each token word. Each vowel is represented by five connected dots. Each dot represents a location signifying the 20-35-50-65-80%-point of vowel duration. Monophthongs are shown as having little formant movement (all 5 measurement points are close to one another). Full diphthongs are identified from expansion over two vowel categories (the 20% and 80% points are far away from one another). In this study we will use terms "monothongization" to depict the close proximity of duration points and the term "diphthongization" to express the large formant movements in vowels. Fronting will be utilized to express the forward movement of vowels throughout the vowel space as well as other directional terms: "back, raised, lowered" to exemplify vowel movement.

Chapter 3

Results

1. Central Ohio

The mean acoustic space of the vowels found in typically developing boys (aged 8-12) in central Ohio (where the Midland dialect is found) is shown in Fig. 3.1. These acoustic measures come from (Fox, & Jacewicz, 2009; Jacewicz et al., 2011b). Shown are the mean measurement points at 20-35-50-65-80% of the vowels' duration for a set of monophthongs ([i ɪ e ɛ æ ɑ u ʊ o ɔ]) and the three true diphthongs ([aɪ aʊ ɔɪ]). Acoustic features commonly found in this regional dialect include minimal formant movement (of the monophthongs /ɪ ɛ æ/ and a merger of the low back vowels /ɑ ɔ/ (speakers of this regional dialect do not often produce or perceive a phonetic quality distinction between the vowels [ɑ ɔ] found in other dialects in the words "cot" vs. "caught"). The mean formant movements from the 20% position to the 80% positions observed in the three true diphthongs as well as the diphthongized vowels [e o] are shown in Fig. 3.2. Note that in this dialect, there is considerable formant movement in all five vowels (including [e o]) in the acoustic vowel space.

In comparison, the vowel space for S305 (an 11-year-old male from Columbus, Ohio with WS) is shown in Fig. 3.3. As is evident from the figure, this participant does not have strong monophthongal versions of the vowels /i ɪ ɛ/ as found in Fig. 3.1. Rather, these three vowels for S305 show considerable formant movement from the 20% point to the 80% point. For even greater contrast, S305 does not show a merger of the vowels /ɑ ɔ/— instead we find a separation of these two vowels. In general, as seen in Fig. 3.4, S305 produces the five diphthong and diphthongized vowels with the same basic direction and extent as seen in the OH controls.

However, S305 does produce the monophthong /o/ and the diphthong /ɔɪ/ much lower in the vowel space than is found in the mean Ohio vowel space.

The vowel space for S306 (a 43-year-old male from Lima, Ohio with WS) is shown in Fig. 3.5. As found in S305, this participant has much formant movement for the monophthong /i/ than is found in the control group but demonstrates relatively monophthongal /ɪ ɛ/ vowels. What is striking in this participant is the strong overlap of a diphthongized /e/ with /i/. S306 also produces a strong diphthongal /æ/ (close to[æə]) which overlaps with /ɑ/. S306 (like S305) also shows no clear merger of the vowels /ɑ ɔ/. In terms of diphthongs (shown in Fig. 3.6), S306 shows much greater formant movement than the controls or S305 regarding the diphthongized /o/. In addition, the offset of his /ɔɪ/ diphthong ends in the mid-central portion of his vowel space (producing it as [ɔə] instead of [ɔɪ]).

2. West Virginia

The mean acoustic space of the vowels found in females (aged 50-65 years) in North Carolina (where the dialect is affected by the Southern Vowel Shift) is shown in Fig. 3.7. These acoustic measures were previously reported in Fox & Jacewicz (2009) and Jacewicz et al. (2011a). The same monophthongized vowels displayed in the central Ohio control ([i ɪ eɪ ɛ æ ɑ u ʊ o ɔ]) are represented in Fig. 3.7 as well as the three true diphthongs ([aɪ aʊ ɔɪ]). Common acoustic characteristics found in this typical adult dialect include a cluster formation of the front vowels / i ɪ e ɛ/ that are heavily diphthongized. The vowel /æ/ is raised and diphthongized, but the true diphthong /aɪ/ is produced as a monophthong. There is no merger of the /ɑ ɔ/ vowels. The vowel /u/ is fronted, corresponding with the controls in the central Ohio dialect, but /o/ is also included in the fronting position in the Southern dialect.

The other control utilized in this study was a sample of young males (aged 8-12 years) in North Carolina shown in Fig 3.9. These children showed receding Southern features, perhaps not fully developed, such as a lack of clustered front vowels. Instead, these individuals displayed a separation of /i ɪ ɛ/ which are also less diphthongized and the lowering of the vowel /aɪ/ in the vowel space. The diphthongs [aɪ aʊ ɔɪ] show more spectral change than in older adults (shown in Fig. 3.10).

The vowel space for S302 (a 37-year-old female from Huntington, WV with WS) showed very little of the Southern features (only /u o/ are fronted as in the South), but instead, her vowels appeared more Ohio-like in regards to vowel space dispersion (shown in Fig. 3.11). The monophthongs observed in Fig 3.11 ([i ɪ ɛ æ]) are diphthongized and there is no low back vowel merger of /ɑ ɔ/ as observed in the controls. The vowel /o/ and the onset of /ɔɪ/ are lowered (shown in Fig. 3.12).

S301 (a 13-year-old male from Huntington, WV with WS) displays a contrasting vowel space compared to S302 and shows similar characteristics of the typical adult control, such as the cluster formation of /i ɪ eɪ ɛ/ seen in older Southern speakers (shown in Fig. 3.13). The vowel /u/ is very fronted. S301 produces all diphthongs nearly monophthongal including a lowered /o/ (shown in Fig. 3.14).

3. Northern Ohio

The mean acoustic space of the vowels found in girls (aged 8-12) in southeastern Wisconsin (where the Northern Cities Shift is prominent) is shown in Fig. 3.15. Common features of Northern American English include vowel /o/ being located in the back of the vowel space, accompanied by /u/; the vowel /e/ is also produced as a monophthong. It is interesting to note that the /æ/ is very diphthongized. In Fig. 3.16, [aɪ aʊ ɔɪ] are shown as full diphthongs but /e o/ are monophthongized.

The vowel space for S303 (a 7-year-old male from Cleveland, OH with WS) is relatively well-representative of the Northern features (shown in Fig. 3.18), however the true diphthongs /aʊ ɔɪ/ displayed a smaller amount of spectral change (shown in Fig. 3.19). The diphthongs represented in S303's vowel space correlate well with the central Ohio control (8-12 year-old boys).

S304 (a 7-year-old female from Cleveland, OH with WS) possesses an individualized vowel space. The vowels are produced in wider ranges with minimal overlaps, as opposed in S303. What is significant in S304 is the monophthongization of /æ/ (shown in Fig. 3.19). The diphthongs /aɪ aʊ/ are pronounced as monophthongs and /ɔɪ/ displays a smaller amount of spectral change (shown in Fig. 3.20).

Figure 3.1. Overall acoustic vowel space for Ohio Controls (young boys aged 8-12 years from central Ohio, see Jacewicz, Fox & Salmons, 2011b).

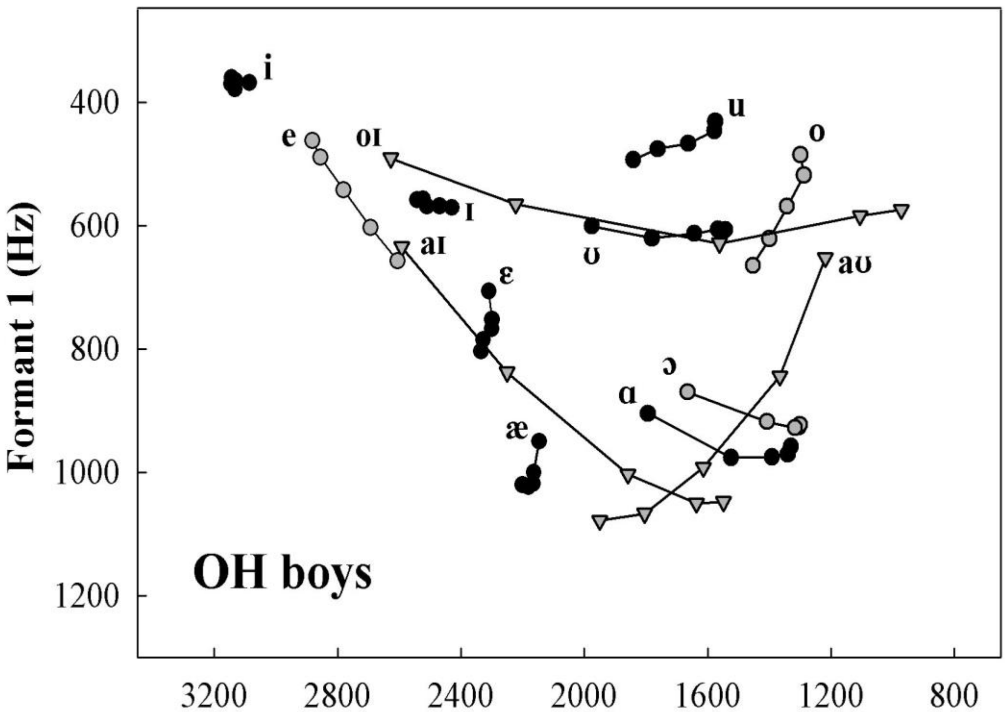


Figure 3.2. Acoustic space of diphthongs for Ohio controls.

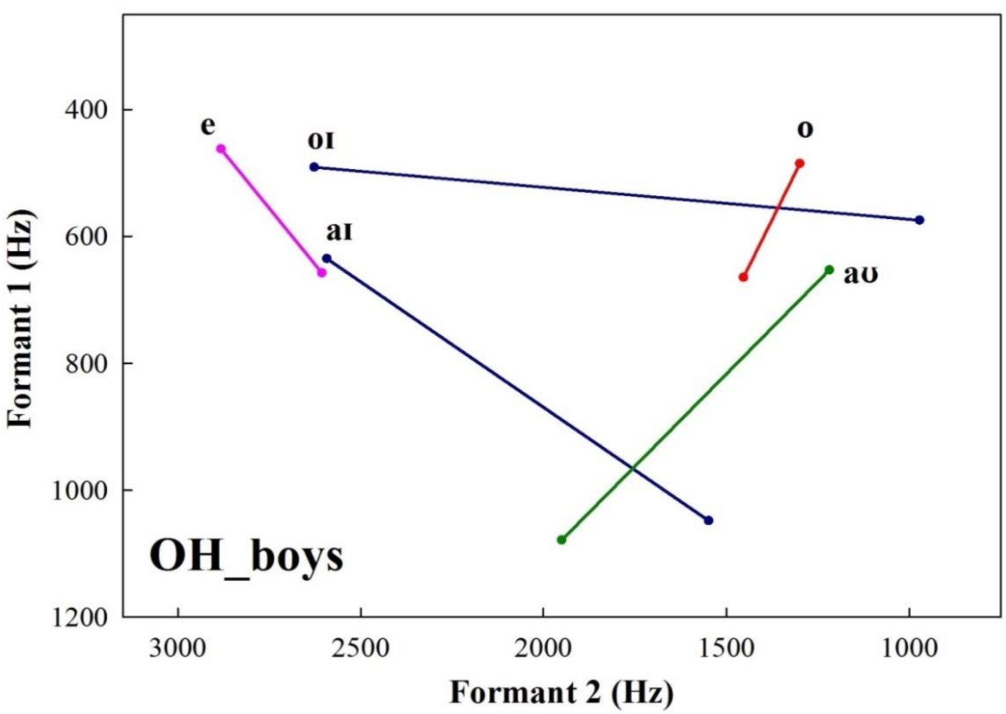


Figure 3.3. Overall acoustic vowel space for S305 (11 year-old male with WS) from Columbus, Ohio.

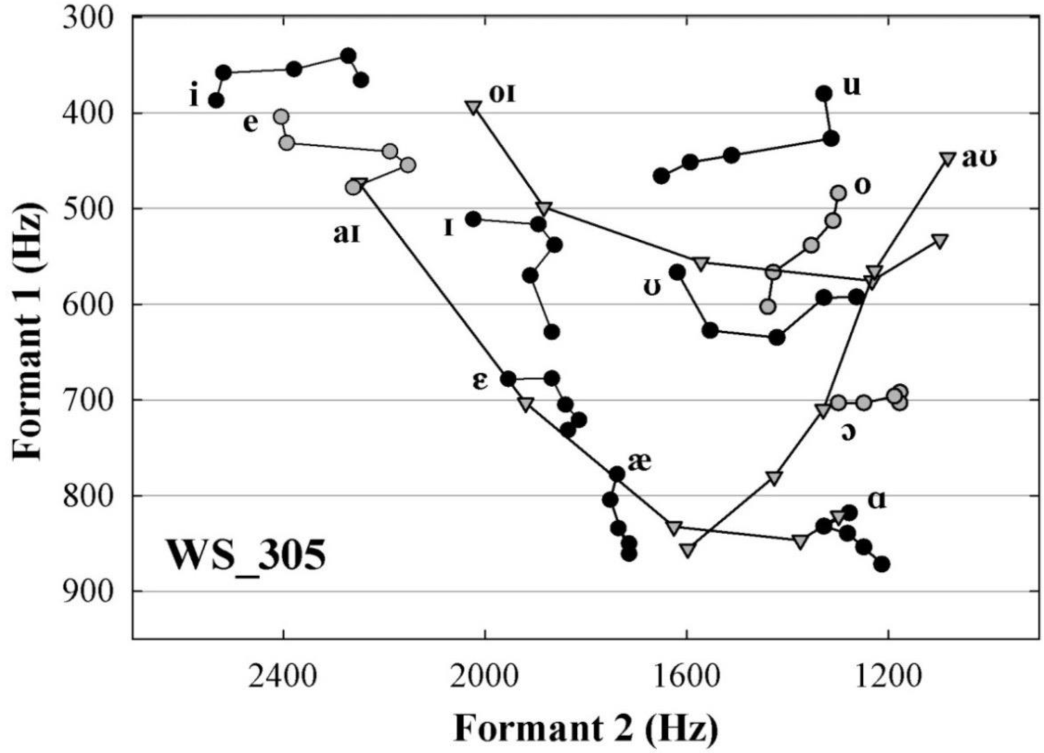


Figure 3.4. Acoustic space of diphthongs for S305.

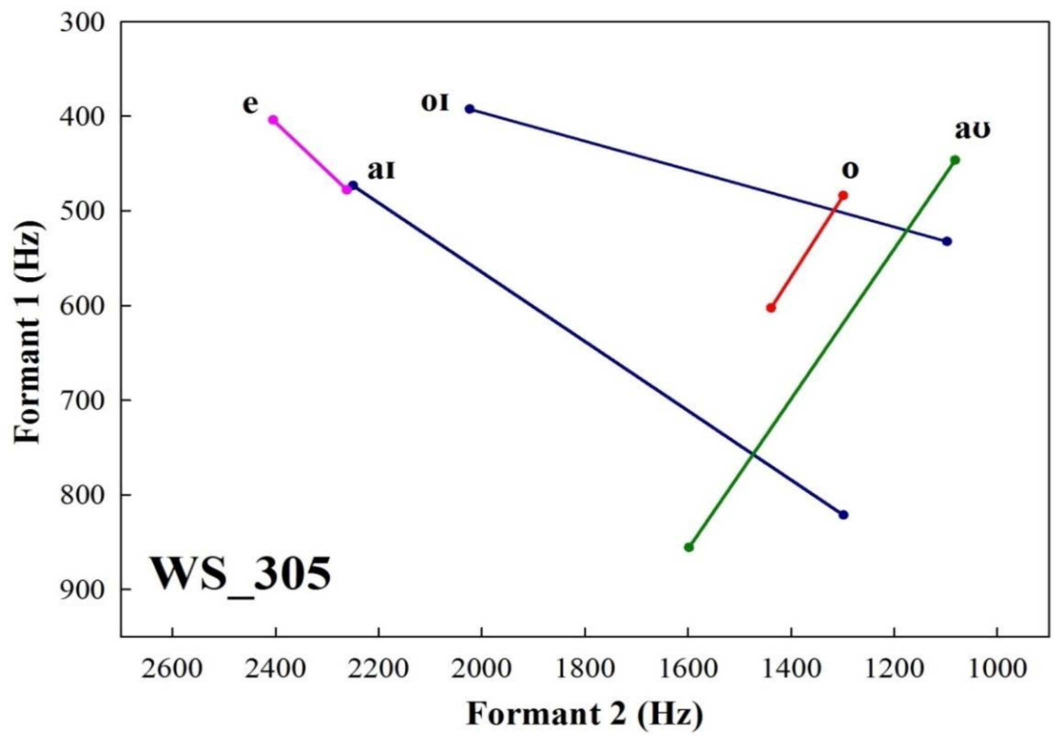


Figure 3.5. Overall acoustic vowel space for S306 (43 year-old male with WS) from Lima, Ohio.

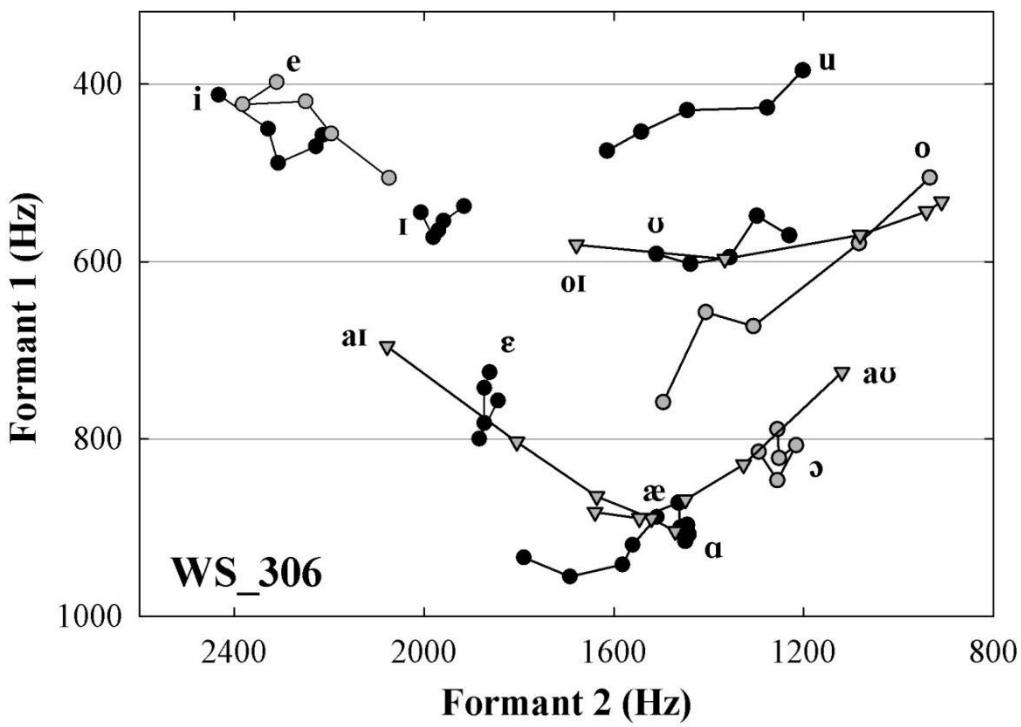


Figure 3.6. Acoustic space of diphthongs for S306.

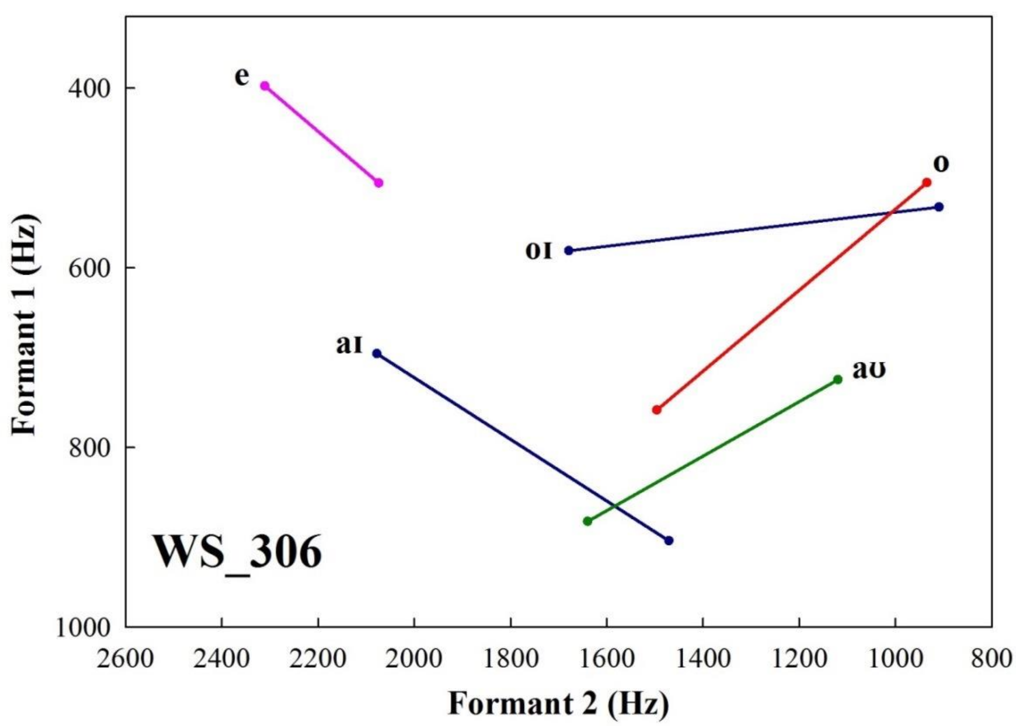


Figure 3.7. Overall acoustic vowel space for North Carolina controls (adult females aged 50-65 years) from western North Carolina, see Jacewicz, Fox, & Salmons, 2011a).

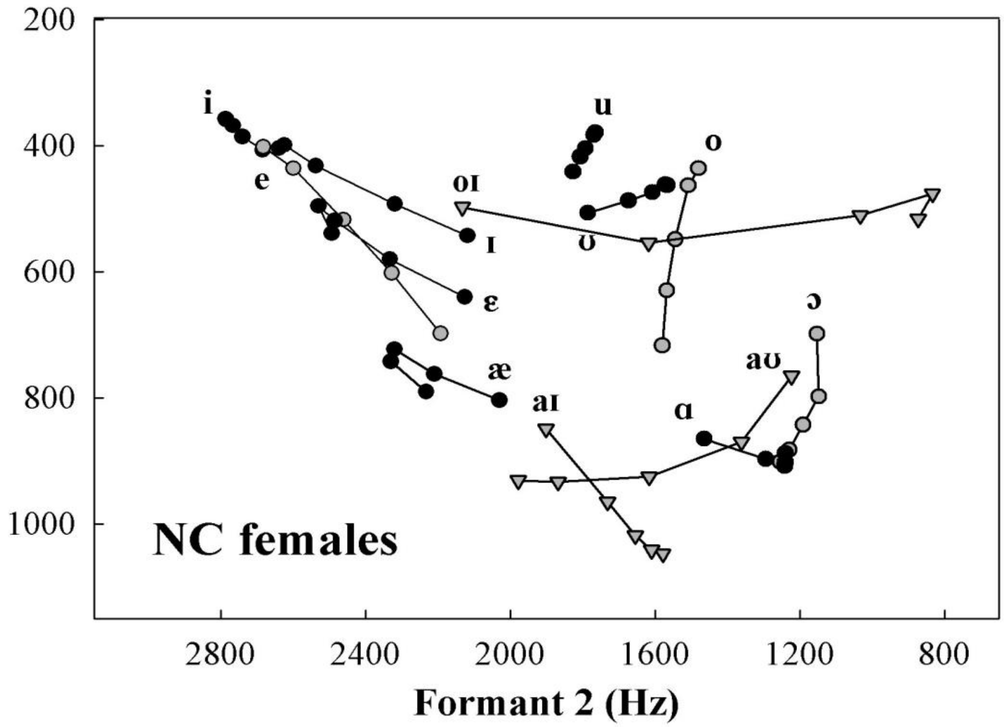


Figure 3.8. Acoustic space of diphthongs for North Carolina controls.

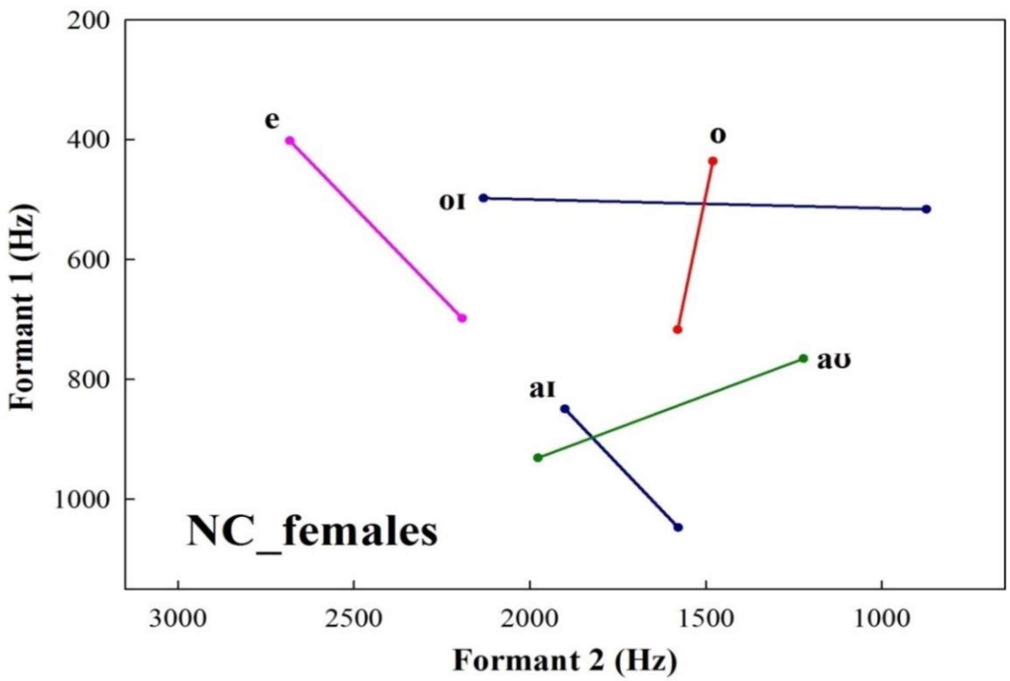


Figure 3.9. Overall acoustic vowel space for North Carolina controls (young boys aged 8-12 years) from western North Carolina, see Jacewicz, Fox, & Salmons, 2011b).

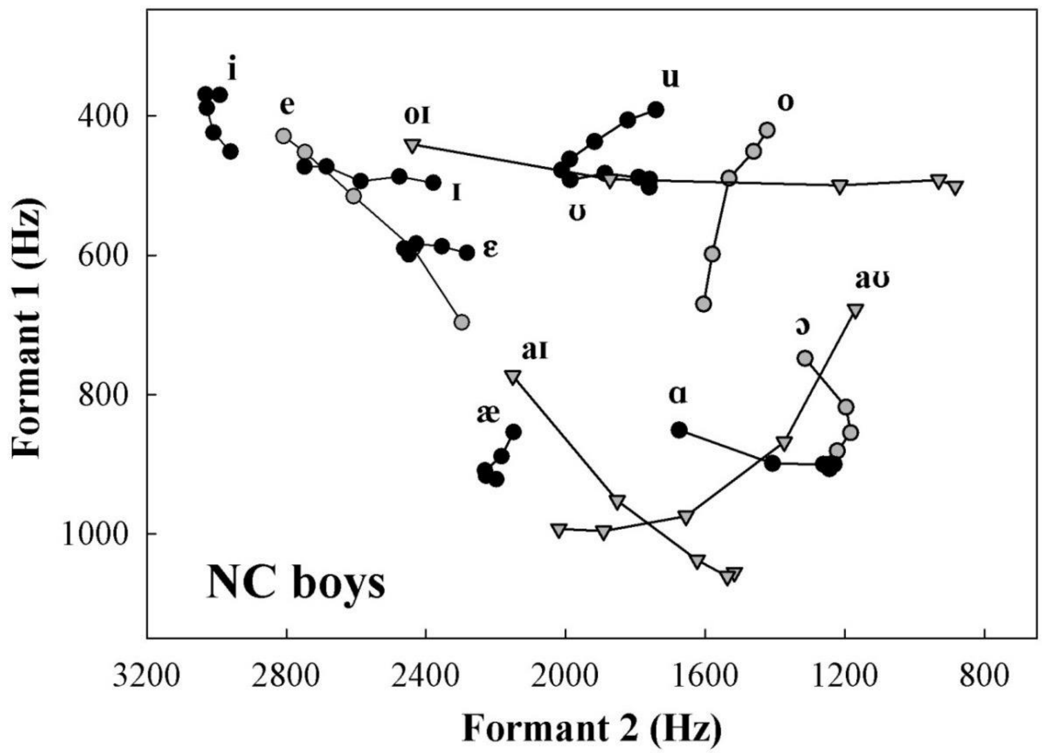


Figure 3.10. Acoustic space of diphthongs for North Carolina controls.

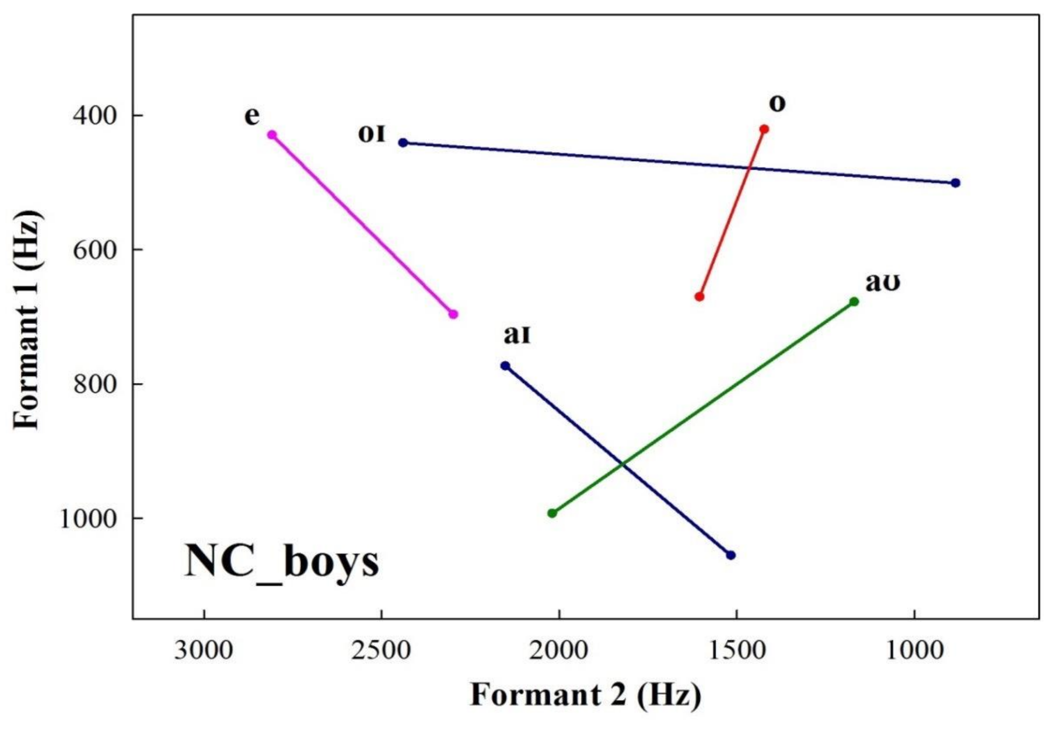


Figure 3.11. Overall acoustic vowel space for S302 (37 year-old female with WS) from Huntington, West Virginia.

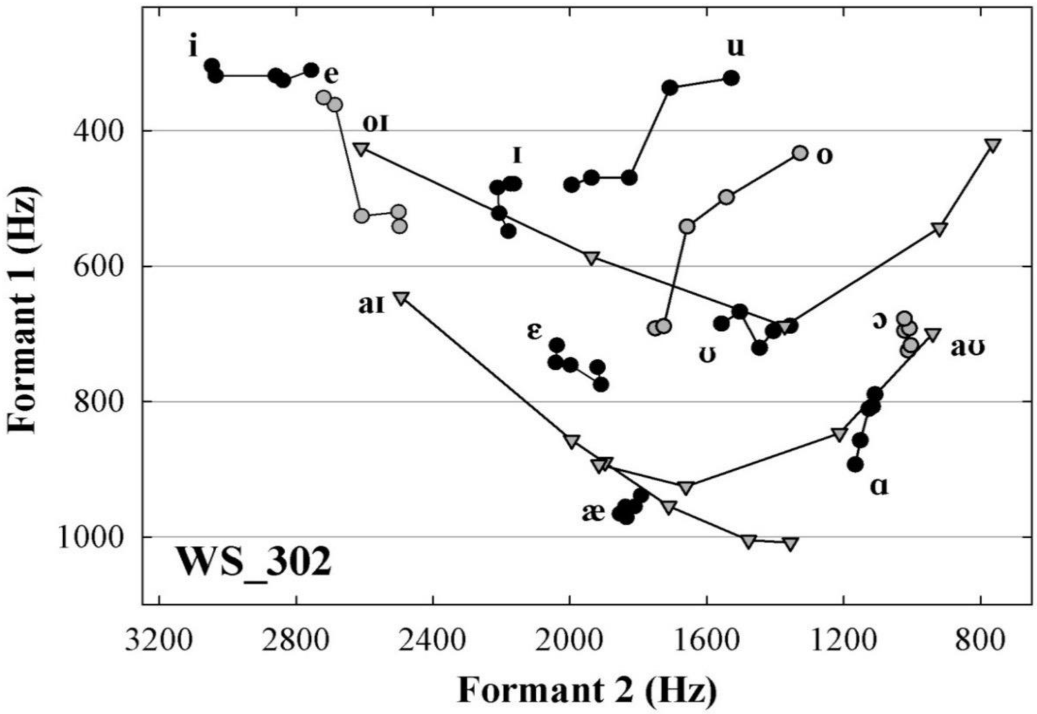


Figure 3.12. Acoustic space of diphthongs for S302.

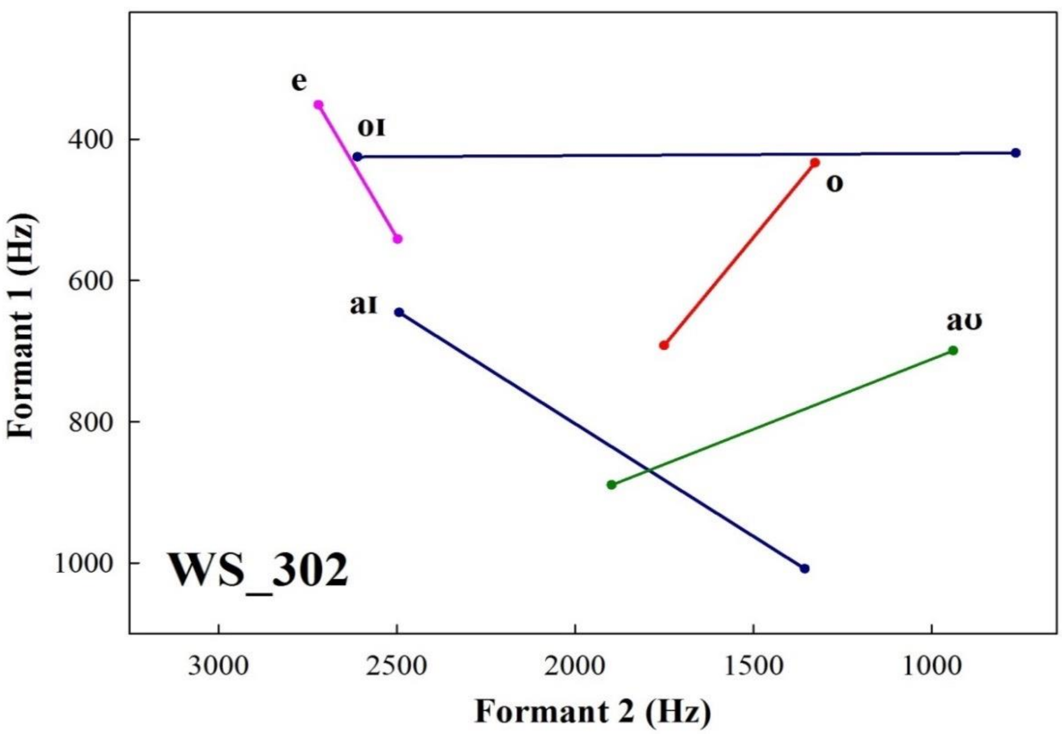


Figure 3.13. Overall acoustic vowel space for S301 (13 year-old boy with WS) from Huntington, West Virginia.

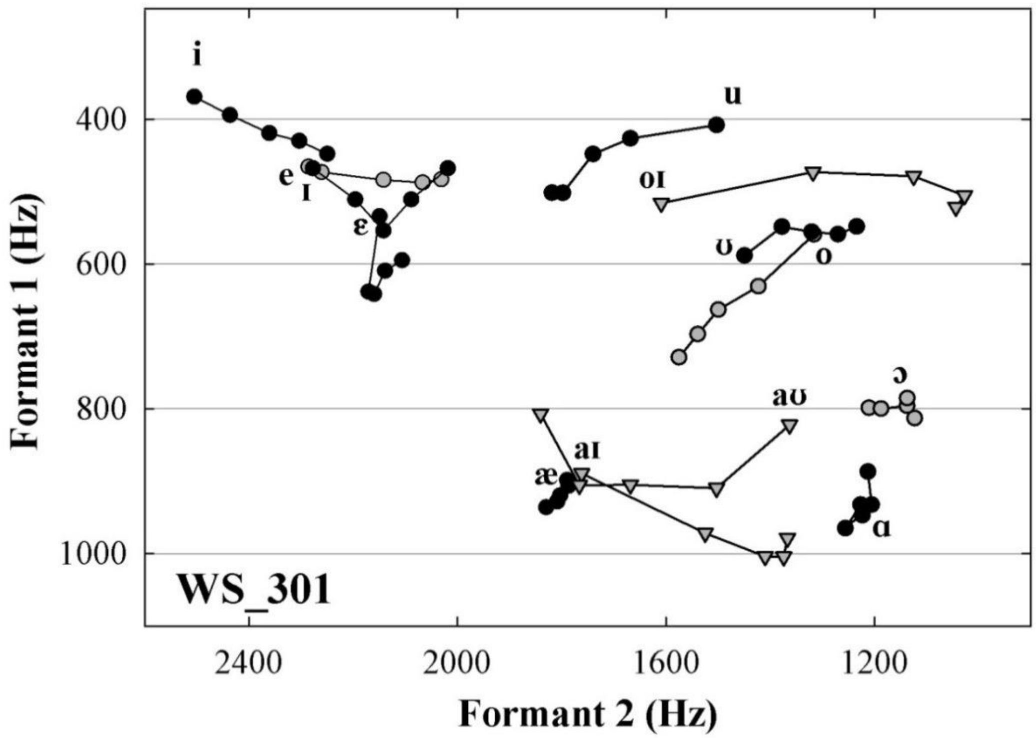


Figure 3.14. Acoustic space of diphthongs for S301.

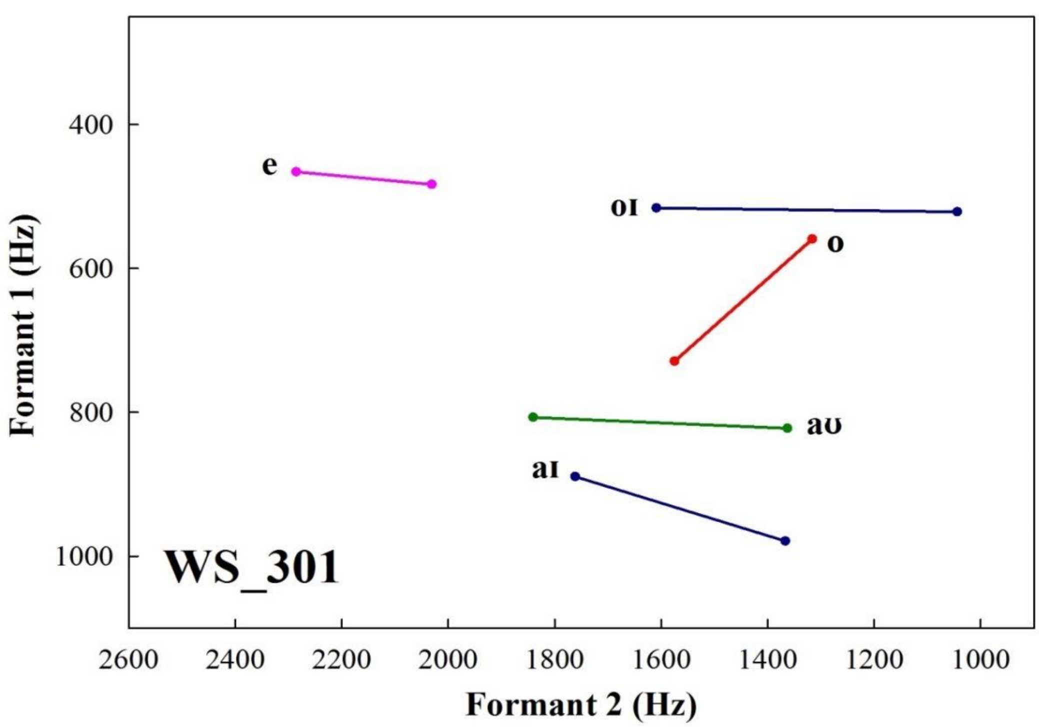


Figure 3.15. Overall acoustic vowel space for Wisconsin controls (young girls aged 8-12 years from southeastern Wisconsin, see Jacewicz, Fox, & Salmons, 2011b).

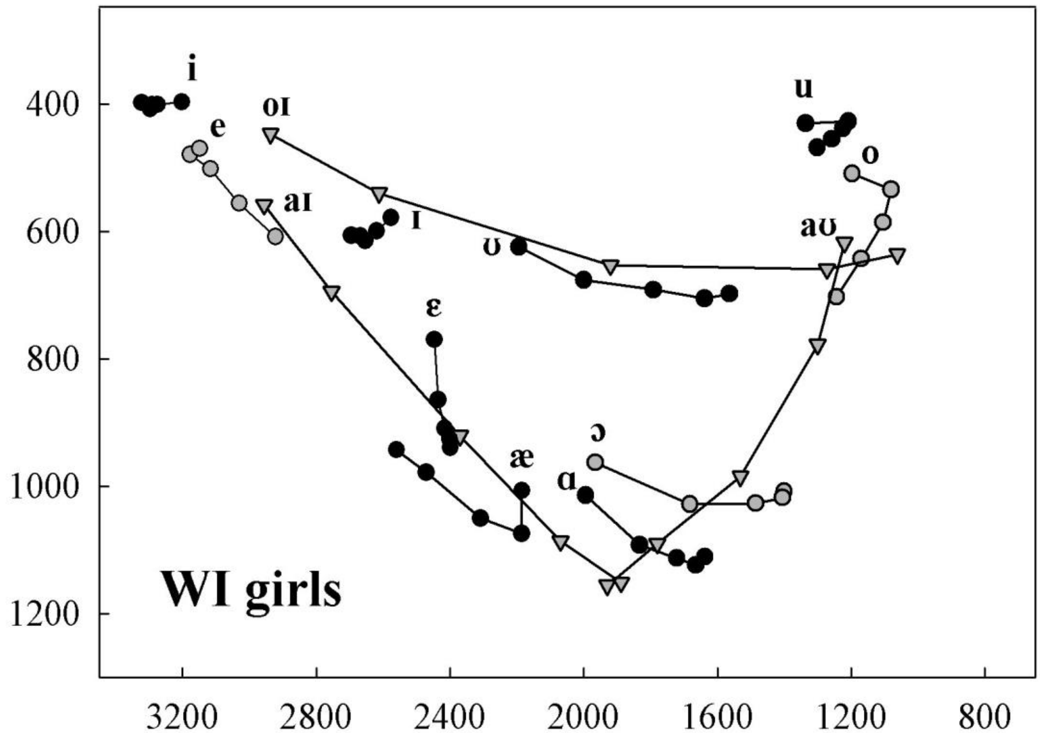


Figure 3.16. Acoustic space of diphthongs for Wisconsin controls.

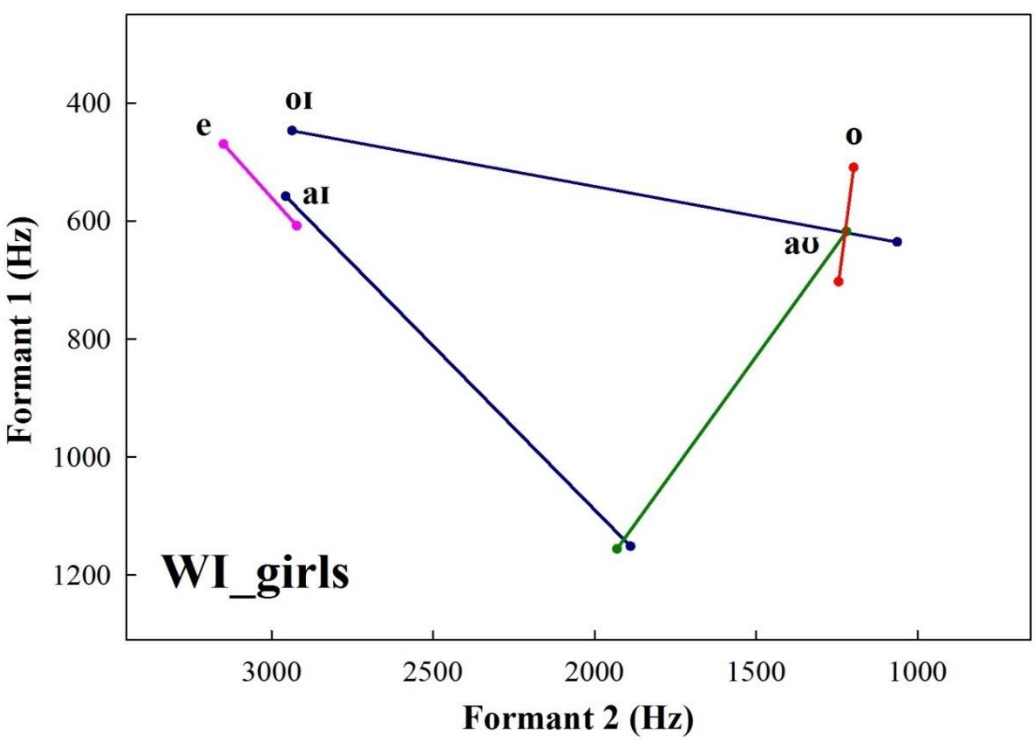


Figure 3.17. Overall acoustic vowel space for S303 (7 year-old boy with WS) from Cleveland, Ohio.

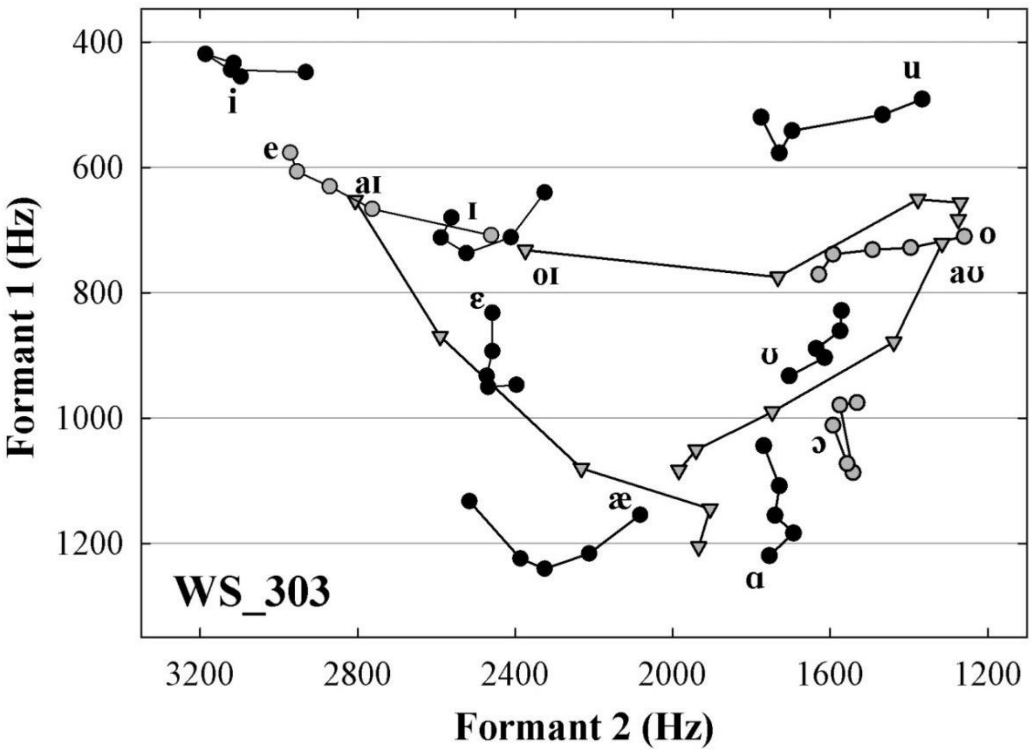


Figure 3.18. Acoustic space of diphthongs for S303.

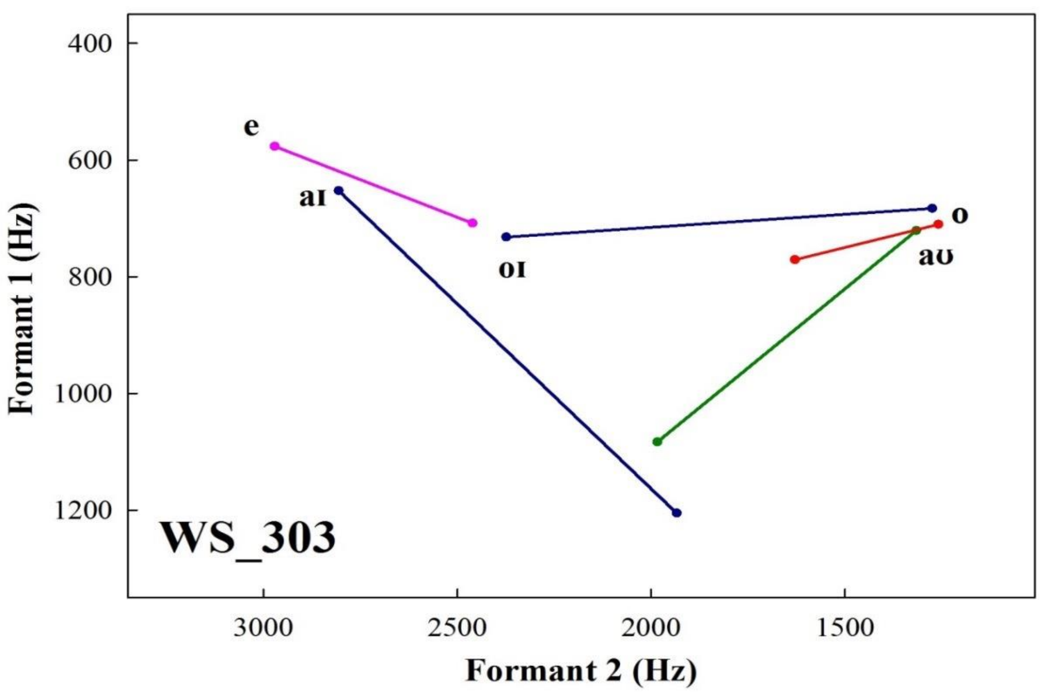


Figure 3.19. Overall acoustic vowel space for S304 (7 year-old girl with WS) from Hudson, Ohio (Cleveland area)

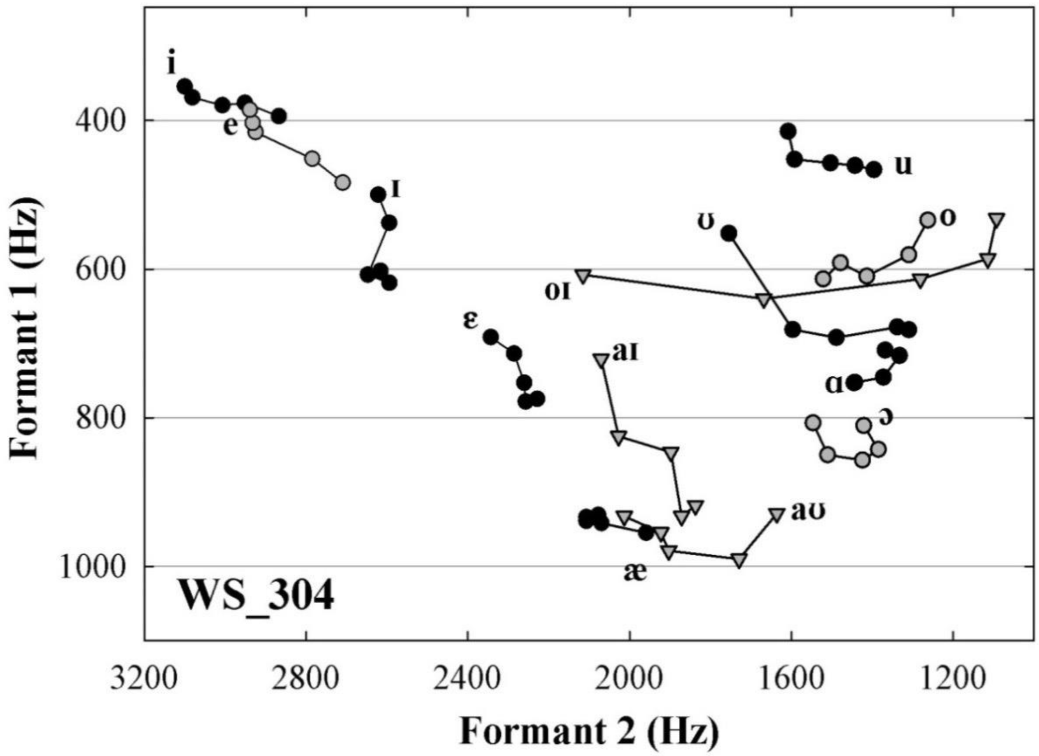
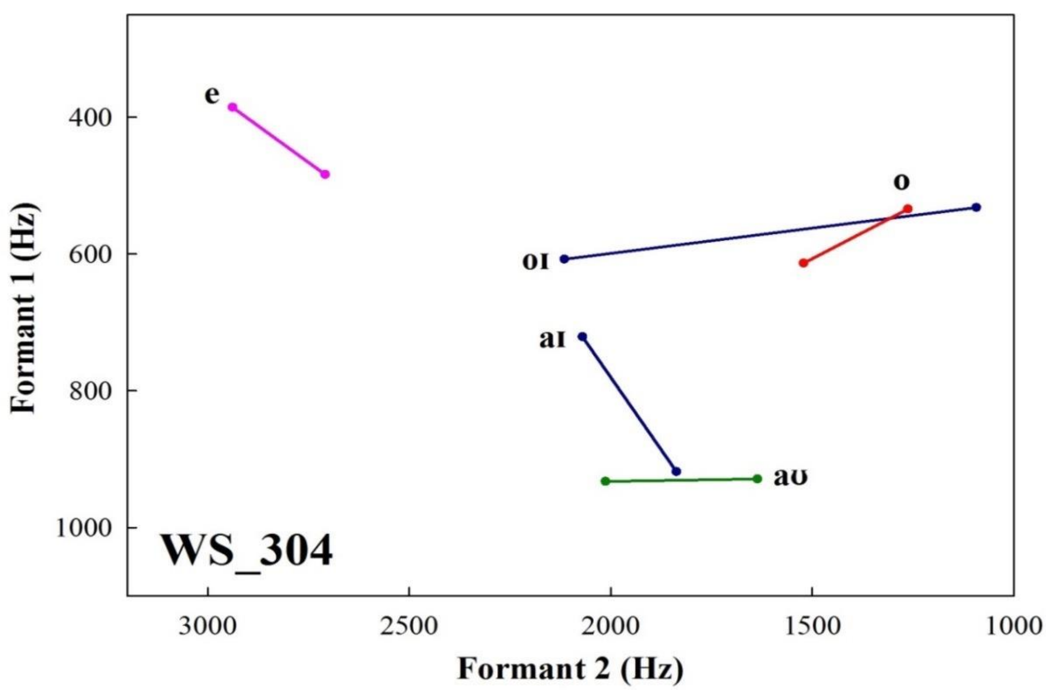


Figure 3.20. Acoustic space of diphthongs for S304.



Chapter 4

Conclusions

This study examined acoustic characteristics of vowels produced by individuals with WS in order to determine their ability to acquire indexical features of speech. Based on sociophonetic research, the pronunciation of American English vowels differs across dialect regions in the United States and typically developing children evidence the dialect-specific variants in their speech patterns. Regional variation represents indexical properties of speech, which were also present in the control participants in the current study.

Vowel characteristics of three different dialects were examined, including the Midland dialect in Central Ohio, the Midwestern dialect in the Northern Cities, and Southern dialect spoken in the South. Compared to controls, individuals with WS did not produce the entire set of dialect features. Only selected features were present in their productions, which were also inconsistent across the two individuals representing each dialect.

An important finding was that the distinction between monophthongs and diphthongs was not always maintained in individuals with WS so that nominal monophthongs had sometimes more spectral change than true diphthongs and the true diphthongs were nearly monophthongal (e.g., S301, S304, S306). The atypical reduction of formant movement in diphthongs indicates that these patterns were due to the syndrome because their occurred in all three dialects studied here. That is, some individuals with WS produced “monophthongized” diphthongs and these productions were unrelated to regional dialect.

Overall, the current results indicate that individuals with WS do not acquire pronunciation details in speech to the same extent as typically developing children and typical adults. They appear to construct relatively individualized vowel spaces and produce only selected features of the speech shared in their speech community. Furthermore, they may not be aware of sound change in their speech community such as the recent merger of the vowels /ɑ ɔ/ in Central Ohio. This would provide an explanation for why neither participant from Central Ohio demonstrated a clear merger, which is a prevalent dialect feature in younger generations in this region.

The current results provide pilot data for future investigations of pronunciation patterns in individuals with WS. We learned that WS impairs their abilities to reproduce the full set of dialect features, which suggests that acquisition of phonetic details is deficient in WS. More data are needed to determine which regional features are easier to detect than others and what mechanism is responsible for minimizing the distinction between monphthongs and diphthongs.

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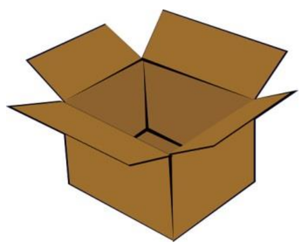
Appendix

Picture 1. Apple

Picture 2. Train

Picture 3. Box



Picture 4. Book

Picture 5. Spoon

Picture 6. Bird

Picture 7. Cat

Picture 8. Snow

Picture 9. Eye

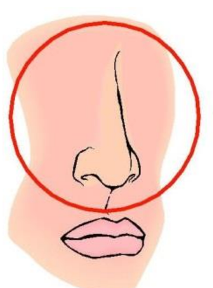
Picture 10. Cake

Picture 11. Bed

Picture 12. Cloud

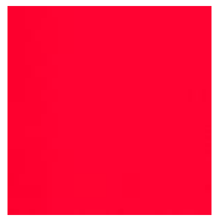
Picture 13. Kite

Picture 14. Nose

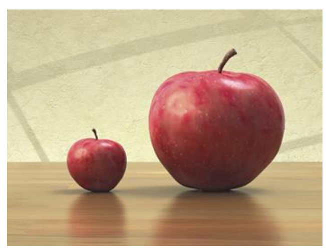


Picture 15. Saw

Picture 16. Red



Picture 17. Big



Picture 18. Boot

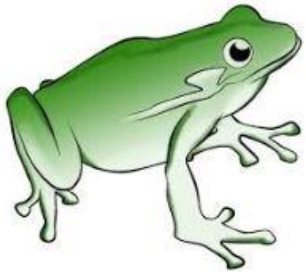
Picture 19. Toy

Picture 20. Sheep

Picture 21. Fish

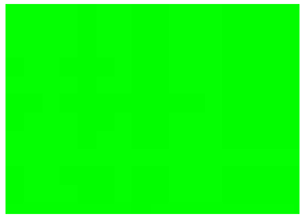
Picture 22. Sun

Picture 23. Frog



Picture 24. Boy

Picture 25. Green

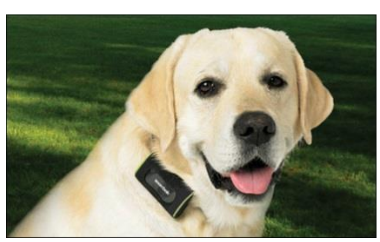


Picture 26. Cup

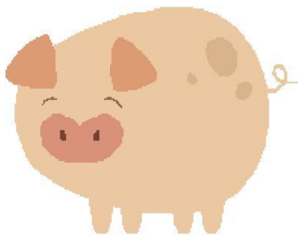
Picture 27. Hat

Picture 28. Rock

Picture 29. Dog



Picture 30. Pig



Picture 31. Table

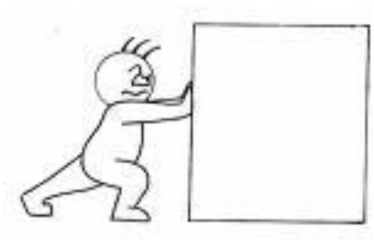
Picture 32. Stop

Picture 33. Truck

Picture 34. Key

Picture 35. Coat

Picture 36. Push



Picture 37. Cows

Picture 38. Shirt

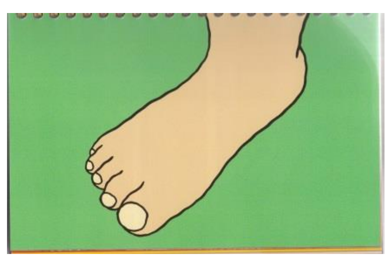
Picture 39. Shoes

Picture 40. Pen

Picture 41. Pie

Picture 42. Cow

Picture 43. Foot



Screenshot of Picture Record Program in Picture-Naming Experiment